Fundamentals of Analyzing and Solving Local Traffic Problems

Fundamentals of Analyzing and Solving Local Traffic Problems

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Baystate Roads Program
UMass Transportation Center

Learn More: Ask Questions

I am always ready to learn although I do not always like being taught.

Winston Churchill

Instructor

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Logistics

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- Sign-in procedures
- Facility information
- Evaluations
- Handouts

Objectives

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- At this workshop, participants will receive information to:
  - understand the basic concepts, principles, and techniques for evaluating traffic issues
  - develop reasonable solutions for addressing local traffic problems

Objectives

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- At this workshop, participants will receive information to:
  - practice completing exercises to perform common municipal engineering and traffic studies using real data
  - be able to more effectively communicate with traffic safety experts

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Workshop Outline

- Part I: Basic Concepts and Principles
- Part II: Tools for Solving Problems and Completing Studies
- Part III: Applications

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Part I: Basic Concepts and Principles

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What are Some Local Traffic Problems?

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What are Some Results of Local Traffic Problems?

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Crashes

- Fatalities – persons killed
- Injuries – having injuries of various severities
- Property damage – only damage to the vehicle without injury

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Purpose of Safety

- Reduce the number and severity of roadway crashes
- Decrease the potential for roadway crashes

Fundamentals of Analyzing and Solving Local Traffic Problems

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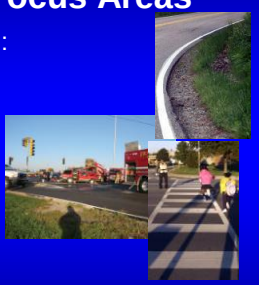
Safety Focus Areas

FHWA is focusing on:

- Roadway Departures
- Intersections
- Pedestrians



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Crashes

Across the U.S., there were:

- ~26,000 roadway departure fatalities
- ~9,000 intersection fatalities
- ~4,000 pedestrian fatalities

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Putting this into Perspective

- Crashes are the leading cause of death for people between the ages of 3 and 33
- An average of 117 persons dies each day in motor vehicle crashes – one every 12 minutes
- Daily financial loss is $630 million per day

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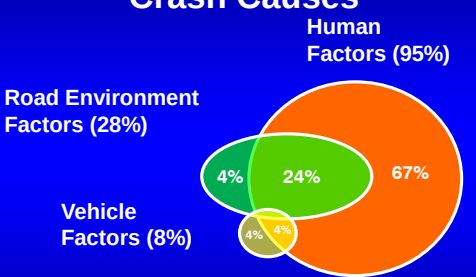
Crash Causes



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Traffic Problems

- Gridlock – capacity problem
- Potholes – maintenance problem
- Work zones – unusual/confusing to driver
- Distracted driving (cell phones, texting) – driver behavior

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Traffic Problems

- Water on road – drainage problem
- Rubberneckers – inattentive drivers
- Poor roadway design - geometry problem
- Speeding – driver behavior and/or geometry
- Cut-through traffic – driver behavior and/or operations/capacity

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How Can We Address These Problems?

That's what this class is for!

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How to Address These Problems?

- Engineering
- Education
- Enforcement
- Emergency Response

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Traffic Engineering

- That phase of engineering that deals with the safe and efficient movement of people and goods on streets and highways
- Who are traffic engineers?

EVERYONE!

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Basic Parameters of Traffic

- Flow (q)
- Density (K)
- Speed (V)

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Definitions

- **Flow** - the number of vehicles traversing a point of roadway per unit time. *Unit: vehicles per hour.*
- **Density** - the number of vehicles occupying a given length of lane or roadway averaged over time. *Unit: vehicles per mile.*
- **Speed** - the distance traversed by a vehicle per unit time. *Unit: miles per hour.*

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q-K-V Relationship

Flow (veh/hr)
= Density (veh/mile) x Speed (miles/hr)

Therefore, q = K x V

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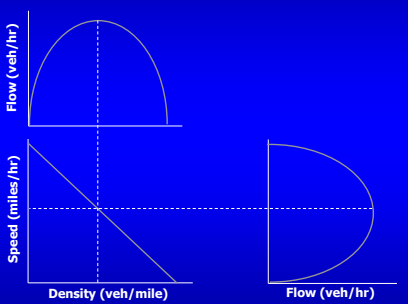
q-K-V Curves



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What does all that traffic need to travel safely and efficiently?

INFORMATION

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How Can We Get Information to Motorists?

Traffic Control Devices

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Traffic Control Devices (TCDs)

- Signs
- Signals
- Markings
- Other (delineators, object markers)

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Traffic Control Device

- **A sign, signal, marking, or other device used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, or shared-use path by authority of a public agency having jurisdiction.**

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Functional Classification of TCDs

- Regulatory
- Warning
- Guide

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How Can We Get Information on TCDs?

MUTCD and State Traffic Commission Regulations

33

What is the MUTCD?

- MUTCD stands for:

  Manual on **U**niform **T**raffic **C**ontrol **D**evices
- Defines the standards used by road managers nationwide to install and maintain traffic control devices on all streets and highways

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Why Adopt the MUTCD?

- Federal Law: 23 CFR 655.603 requires all Traffic Control Devices (TCD) on streets and highways open to public travel to be in substantial compliance with the MUTCD

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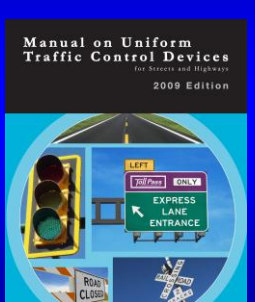
Massachusetts Uses the MUTCD & a State Supplement)



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LAW	Massachusetts Statutes Chapter 85	**Statutory Requirement-** rigid-legislated
Regulations	Massachusetts Department of Highway	**Force and effect of Law-** Rigid –Independent Regulatory Review Commission
Policies	Statement of Policy	**Policy** Some flexibility-Agency Change

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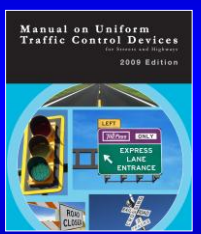
The 2009 Edition of the MUTCD

Federal Highway Administration

Office of Transportation Operations

MUTCD Team



http://mutcd.fhwa.dot.gov

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Overall Format of MUTCD

- Broken into nine Parts (1-9), which are sub-divided into Chapters (Alphabetical)
  - Example: Chapter 2C is Part 2 - Signs, Section C – Warning Signs and Object Markers
- Page, table, and figure numbering are based on Parts and Chapters (2C -1)

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MUTCD - 2009 Edition

- Part 1. General
- Part 2. Signs
- Part 3. Markings
- Part 4. Highway Traffic Signals
- Part 5. Traffic Control Devices for Low-Volume Roads
- Part 6. Temporary Traffic Control
- Part 7. Traffic Controls for School Areas
- Part 8. Traffic Control for Railroad and Light Rail Transit Grade Crossings
- Part 9. Traffic Controls for Bicycle Facilities

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Massachusetts Amendments to the MUTCD and Standard Municipal Traffic Code

- Part 11: Traffic Regulations
- Part 12: Rules and Regulations for Entrance to State Highways
- Part 13: Traffic Control Agreement (Sample TCA)

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MUTCD Definitions

- **Standard** = Shall condition
- Guidance = Should Condition
- Option = May Condition
- Support statements provide general background information.

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PART 1

General

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Part 1: General

- Contains general guidelines for the purpose, principles, design, and placement of traffic control devices
- Glossary of terms
  - For example, "Rural Highway – a type of roadway normally characterized by lower volumes, higher speeds, fewer turning conflicts, and less conflict with pedestrians"
- Uniformity and responsibility for traffic control devices

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PART 2

Signs

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Part 2: Signs

- Regulatory
- Warning and Object Markers
- Guide
- Toll Road
- Preferential and Managed Lane and General Information
- Specific Service, TODS, CMS, Directional, Recreational, Emergency Management Signage, etc.

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Part 2: Signs

- Contains sign layout diagrams for some scenarios (e.g., one-way signing at intersections)
- MUTCD does not specify lettering and spacing dimensions
- MUTCD does not have state-specific information

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PART 3

Markings

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Part 3: Markings

- Pavement and curb markings
- Roundabout markings
- Markings for Preferential Lanes
- Markings for Toll Plazas
- Delineators
- Colored Pavements
- Islands
- Rumble Strip Markings

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PART 4

Highway Traffic Signals

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Part 4: Highway Traffic Signals

- Warrants
- Signal features
- Pedestrian control features
- Special applications
  - Pedestrian hybrid applications
  - Emergency vehicle access
  - Freeway entrance ramps
  - Lane-use control signals
  - In-roadway lights
- Flashing beacons

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PART 5

Low Volume Roads

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Low-Volume Roads

- **Outside of Built-up Areas of Cities, Towns, and Communities**
- **Traffic Volume < 400 Annual Average Daily Traffic (AADT)**
- **Classified as Paved or Unpaved**
- **Not part of a State highway system**

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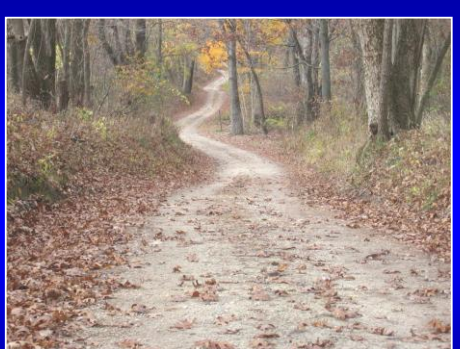

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Part 5: Traffic Control Devices for Low Volume Roads

- Dedicated portion of the MUTCD to low volume rural roads
- Focus on TCDs that are unique or most applicable to low volume roads
- Warns of conditions not normally encountered
- Prohibits unsafe movements

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PART 6

Temporary Traffic Control

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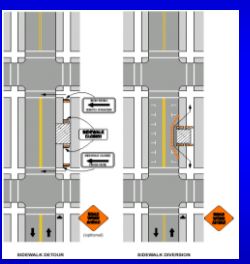
Temporary Traffic Control

- Principles
- Tools
- Ped and worker safety
- Flagger control
- Devices
- Types of activities
- Typical applications



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PART 7

Traffic Control for School Areas

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School Areas

- Signs
- Markings
- Crossing Supervision

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PART 8

Traffic Control for Railroad and Light Rail Transit Grade Crossings

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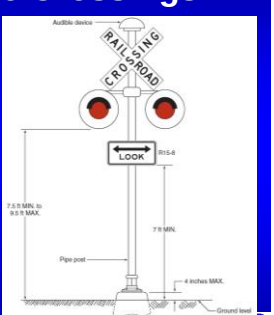
Railroad Grade Crossings

- Signs and markings
- Flashing light signals, gates, etc.
- Pathway grade crossings



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PART 9

Traffic Control for Bicycle Facilities

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Bicycle Facilities

- Signs
- Markings
- Signals

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MUTCD Web Site

http://mutcd.fhwa.dot.gov

- **Current & Previous Versions of MUTCD**
- **Compliance Dates**
- **Proposed Revisions to MUTCD**
- **Federal Register Notices re: MUTCD**
- **Official Rulings Database (Experimentations, Interpretations) – under development**
- **Standard Highway Signs Book (incl. Alphabets & marking symbols)**
- **FAQ's**
- **Discussion Area – post a question for peer responses**

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MUTCD Hard Copy

- **American Traffic Safety Services Association** (ATSSA)
  - Call Toll Free 1.877.642.4637
  - Perfect Bound price is $80.00 for 1 – 9 copies
- **American Association of State and Highway Transportation Officials** (AASHTO)
  - Call Toll Free 1.800.231.3475
  - Non-member price is $75.00
- **Institute of Transportation Engineers** (ITE)
  - Call 1.202.289.0222
  - Perfect Bound price is $70.00 for 1 – 9 copies
  - Loose-leaf format is available at the same price, binder and tabs $15.00 extra

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Massachusetts Amendments to the MUTCD and Standard Municipal Traffic Code

- Part 11: Traffic Regulations
- Part 12: Rules and Regulations for Entrance to State Highways
- Part 13: Traffic Control Agreement (Sample TCA)

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PART 11

Traffic Regulations

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Traffic Regulations

- Legal Authority
- Types of Permits
- Parking, one-way street, turning movements, parking meters
- Stop signs
- Through Ways
- Pedestrian Regulations
- Towing Regulations
- Speed Control
- Heavy Commercial Vehicle Exclusion

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Massachusetts Amendments to the MUTCD and Standard Municipal Traffic Code

- Part 12: Rules and Regulations for Entrance to State Highways
- Part 13: Traffic Control Agreement (Sample TCA)

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Definitions

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Engineering Study

- **The comprehensive analysis and evaluation of available pertinent information, and the application of appropriate principles, Standards, Guidance, and practices as contained in this Manual and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. An engineering study shall be performed by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. An engineering study shall be documented.**

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Engineering Judgment

- **The evaluation of available pertinent information, and the application of appropriate principles, Standards, Guidance, and practices as contained in this Manual and other sources, for the purpose of deciding upon the applicability, design, operation, or installation of a traffic control device. Engineering judgment shall be exercised by an engineer, or by an individual working under the supervision of an engineer, through the application of procedures and criteria established by the engineer. Documentation of engineering judgment is not required.**

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Engineering and Traffic Study

- Examination of geometry and traffic to establish a need for action
- Establishment or revision of restriction
- Removal of restrictions
  - None of the study “Tools” justify existing restriction
  - Condition that originally justified the restriction no longer exists

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Highway

- **A general term for denoting a public way for purposes of travel by vehicular travel, including the entire area within the right-of-way**

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Through Highway

- Highway on which vehicular traffic is given preferential right-of-way
  - Vehicles entering a through highway are required to yield right-of-way in accordance with legally established traffic control devices

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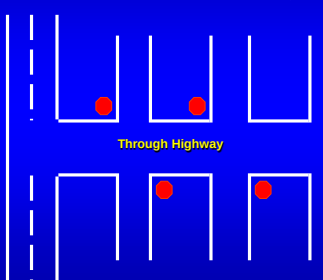
Through Highway



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Major Road

- Roadway at an intersection normally carrying the higher volume of vehicular traffic

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Minor Road

- Roadway at an intersection normally carrying the lower volume of vehicular traffic

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Grade

- Up or down longitudinal slope of a highway expressed in percent (%)
  - Upward slope = Positive grade (+%)
  - Downward slope = Negative grade (-%)

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ADT (Average Daily Traffic)

- Total traffic during a # of whole days / # of days
- Ex.: 2,000 Vehicles/Day

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Multiway Stop

- Intersection where three or more intersection approaches are required to stop

Progressive Signal System

- A signal system where a vehicle, traveling at a predetermined speed, entering the system in the progressed direction ... should arrive at all other signals during the green indication

Warrant

- A description of a threshold condition based upon average or normal conditions that, if found to be satisfied as part of an engineering study, shall result in analysis of other traffic conditions or factors to determine whether a TCD or other improvement is justified.
- Warrants are not a substitute for engineering judgment. The fact that a warrant for a particular traffic control device is met is not conclusive justification for the installation of the device.

Ordinance

- Ordinance is a law enacted by a municipal body, such as a city council or county commission.
- Ordinances govern matters not already covered by state or federal laws such as zoning, safety and building regulations, etc.

Basic Format of an Ordinance

- Paragraph I: Outlines how ordinance relates to the vehicle code which requires this action
- Paragraph II: List specific location and direction of travel
- Paragraph III: Fine or fee structure

Part II: Tools for Solving Problems and Completing Studies

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Tools

1. Crash Analysis
2. Road Safety Audit Review
3. Hazardous Roadway Elements Review
4. Acceleration Lane
5. Alternate Route
6. Angle Parking Measurements
7. Arrival and Departure Hours of Students
8. Capacity Analysis
9. Gap Study for School Children

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Tools

10. Geometric Review
11. Parallel Streets
12. Past Experience
13. Pavement Analysis
14. Pedestrian Volumes
15. Roadside Development
16. Roadside Obstructions
17. School Route Plan
18. Sight Distance

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Tools

19. Speed Data
20. Structural Analysis
21. Traffic Calming
22. Traffic Signals
23. Traffic Volumes
24. Type of Highway
25. Intersection Delay
26. Travel Time and Delay

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Tool #1 Crash Analysis

- An orderly review and evaluation of the root causes of crashes involving vehicles or pedestrians at a given location or within a given area along a highway
- Includes only reportable crashes unless non-reportable crashes are explicitly used.

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Crash Analysis Considerations

- May include development of a crash diagram
- # crashes during the last 5 years
- Types and causation factors of crashes
- Vehicle type
- Pedestrian involvement
- Type of traffic control

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Crash Analysis

- Geometrics
- Cause of crash
- Time of crash
- Environmental conditions
- Crash rate

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Crash Rate

$$R = \frac{C \times 1{,}000{,}000}{T \times V \times L}$$

R = Crash rate per million vehicle miles traveled
C = # crashes in a 5 year time period
T = Time period in days (1825 days = 5 years)
V = Average daily traffic (ADT)
L = Length of roadway section in miles

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Crash Rate Example

- Given:
  - 1 Crash per year for 5 years
  - 1500 vehicles per day
  - 2000 ft. section of roadway

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Crash Rate Example

$$\text{Rate} = \frac{5 \text{ crashes} \times 1{,}000{,}000}{1825 \text{ days} \times 1500 \text{ veh} \times .38 \text{ miles}}$$

$$= 4.81 \text{ crashes per million vehicle miles traveled}$$

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Crash Rate Comparison

- Massachusetts Crash Rates
  - http://www.mhd.state.ma.us/default.asp?pgid=content/traffic/crashRateEval&sid=about
  - Urban, rural
  - Access control
  - Divider type
  - Total width
  - ADT range
- Other State data
- NHSTA

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Intersection Crash Rate

$$R = \frac{C \times 1{,}000{,}000}{T \times V}$$

R = Crash rate per million vehicles
C = # crashes in a 5 year time period
T = Time period in days (1825 days = 5 years)
V = Average daily traffic (ADT)

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Fatality Rate

$$R = \frac{C \times 100{,}000{,}000}{T \times V \times L}$$

R = Fatality rate per 100 million vehicle miles traveled
C = # fatalities in a 5 year time period
T = Time period in days (1825 days = 5 years)
V = Average daily traffic (ADT)
L = Length of roadway section in miles

Fundamentals of Analyzing and Solving Local Traffic Problems

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Crash Summaries

- Spot map
- Collision Diagram
- Other

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Spot Map

- Use map of all roads in Municipality
- Use crash statistics for 5 years
- Examples:
  - One spot or pin for each crash location regardless of type or frequency
  - One spot or pint for each crash

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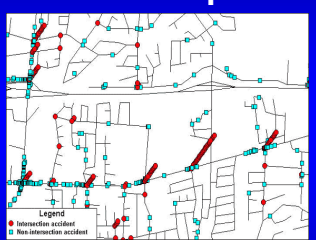
Spot Maps



Spot maps provide a quick visual picture of crash concentrations

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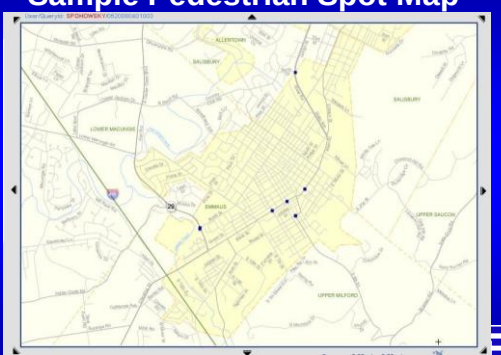
Sample Pedestrian Spot Map



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Collision Diagram

- Use crash statistics for 1 to 5 years
- Each crash displayed on a schematic drawing of an intersection
- Symbols used to show type and severity of crash
- Notes for date, day, time and unusual weather conditions for each crash

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Collision Diagram

- Collision diagrams are used to identify similar crash patterns
- Provide information on the type and number of crashes, conditions, direction of travel and approximate location

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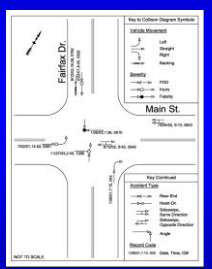
Collision Diagram



The diagram shows:

- Vehicle movement
- Crash severity
- Crash type
- Date and time
- Identification number for each crash

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In Class Example: Crash Analysis

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Tool #2: Road Safety Audit Review

An examination of an existing roadway by an independent, qualified audit team who reports on safety issues.

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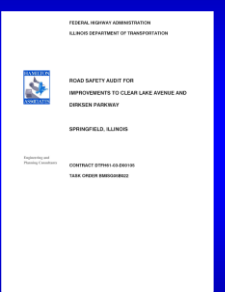
Road Safety Audit Review

Following the assessments, the team prepares a brief report identifying the potential safety issues.



FEDERAL HIGHWAY ADMINISTRATION
ILLINOIS DEPARTMENT OF TRANSPORTATION

ROAD SAFETY AUDIT FOR
IMPROVEMENTS TO CLEAR LAKE AVENUE AND
DIRKSEN PARKWAY

SPRINGFIELD, ILLINOIS

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Road Safety Audit Review

The jurisdiction owning the road then responds to the problems identified and determines the actions it will take or documents the reason for not acting on a suggestion.

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Road Safety Audit Review

The audit team identifies safety issues by considering the interaction of:

- Geometry
- Operations
- User characteristics

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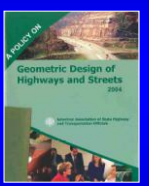
Road Safety Audit Review

Geometry

- Use of design guidelines and standards is a solid starting point
- Consider how geometry will be perceived by road users
- Evaluate how geometry might affect safety during the road's service life



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Road Safety Audit Review

Geometry Issues

- Curve radius

- Sight distance, curve and gradient

- Clear zones

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Road Safety Audit Review

Operations

- Congestion and delay
- Signal operation
- Operating speeds
- Queuing
- Turning movements
- Driveways

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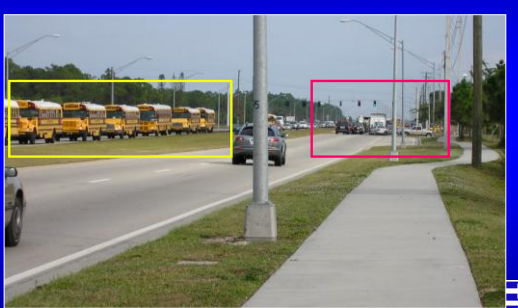
Road Safety Audit Review Operations Example



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Road Safety Audit Review

User characteristics

- Pedestrians
- Cyclists
- People with disabilities
- Trucks
- Transit

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Road Safety Audit Review User Interaction Example

- Adequate space for all road users
- Adequate separation between motorized and un-motorized users

Tool #3: Hazardous Roadway Elements Review

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1. Crash evaluation methods
2. Road safety audit review (RSAR)
3. **Hazardous roadway elements review**

Hazardous Road Elements

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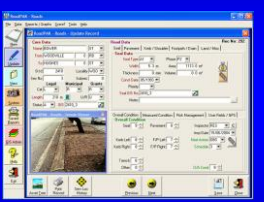
Hazardous road elements can be identified by a review of existing road inventories or through routine field inspection.



Hazardous Road Elements

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Searching for known hazards may identify sites with a potential for high crash severity.

Hazardous Road Elements

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Agency personnel can compare existing roadway features with current safety and design standards.

Unimproved Road

Improved Road

Potential Road Hazards

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- Narrow bridges
- Guide rail deficiencies
- Sight distance restrictions
- Narrow lanes and shoulders
- Non-uniform traffic control devices

Tool #4 Acceleration Lane

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- Length determined using AASHTO Green Book
- Provide adequate length

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Tool #5
Alternate Route

- Availability of route
- Structural capability
- Reasonable level of service
- Reasonable length of detour
- Geometrics
- Compatibility of route

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Tool #6
Angle Parking Measurements

- Parking angle
- Parking and maneuver area

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Angle Parking Measurements

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Angle Parking Measurements

- New angle parking may be established along streets when:
  - Parking & maneuver area is adequate
  - Adequate corner sight distance
  - Area is not required for travel lanes
  - Adequately marked
  - Minimum pedestrian activity

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Angle Parking

- Sample guidance

Parking Angle (degrees)	Parking and Maneuver Area
30	26
45	30
60	37
90	43

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Tool #7 - Arrival and Departure Hours of Students

- Time students arrive/leave school
- Split times for different grades
- Physically observed or school officials

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Tool #8
Capacity Analysis

- The study of facilities and their ability to carry traffic over clearly defined operational characteristics
- Qualitative measure of operational conditions - Level of Service (LOS)
  - "Quality of service provided by a facility"
  - LOS is a function of speed, travel time, delay, safety, volume and other factors

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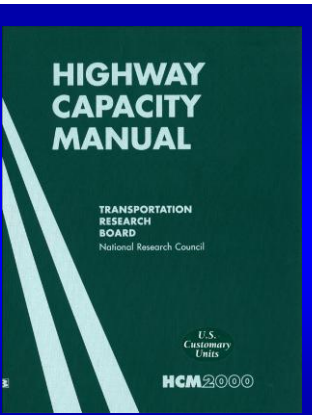


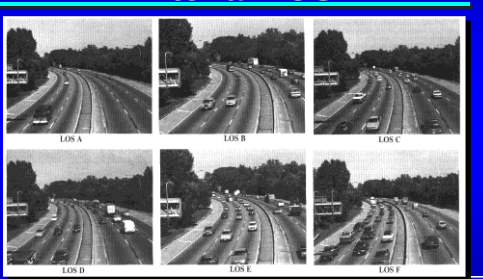
152

Capacity Analysis

Level of Service	General Operating Conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

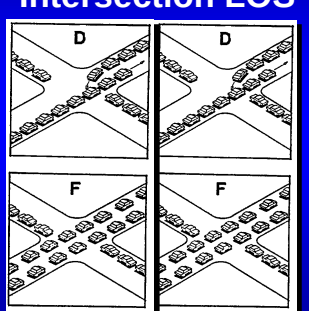
153

Arterial LOS



154

Intersection LOS



155

Tool # 9: Gap Study for School Children

- Study gaps in traffic to determine they are sufficient for safe crossing of school children
- Items to evaluate:
  - Predominant pedestrian group size
  - Length of minimum adequate gap
  - Measuring gaps in traffic
  - Determine sufficiency of gaps

156

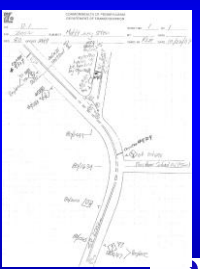
Gap Study for School Children

- References:
  - ITE Manual of Traffic Engineering Studies
  - ITE's Program for School Crossing Protection

157

Tool #10
Geometric Review

- Intersection alignment
- # and spacing of intersections
- Railroad grade crossings
- Roadway cross section
- Roadway surface features



158

Geometric Review (cont'd)

- Roadway width
- Roadway horizontal and vertical alignment
- Roadside obstructions
- References: AASHTO Green Book and State Design Manual

159

Tool #11
Parallel Streets

- Determine if street can handle:
  - Volume
  - Types of traffic
- Consider the following:
  - Weight restrictions
  - Lateral width restrictions
  - Vertical clearance limitations
  - Capacity analysis
  - Access to premises
  - Character of neighborhood

160

Tool #12
Past Experience

- Highway closures for processions, assemblies, or special activities
  - Crashes during similar events
  - Documented or observed congestion problems
  - Written or oral citizen complaints
- Highway breakup
  - Consider previous breakups and restrictions during same climactic conditions

161

Tool #13
Pavement Analysis

- Qualified Engineer reviews:
  - Condition and description of pavement
  - Type, speed, and volume of traffic
  - Vehicle weight
  - *May be permissible to use past experience with pavement or with similar pavements during similar climactic conditions

162

Pavement X-Section

163

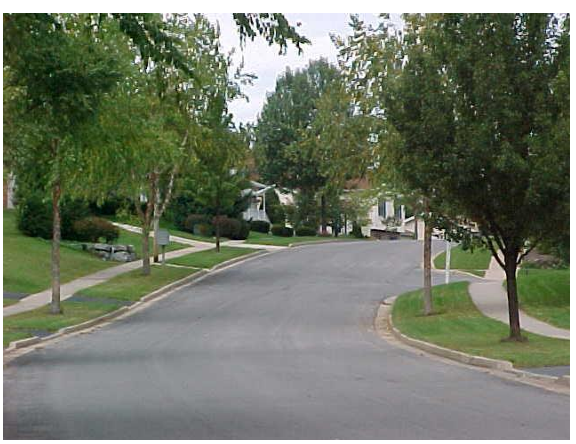
Tool #14
Pedestrian Volumes

- Manual counts
- 15-minute intervals
- May be classified by type of pedestrian
- Intersections, mid-block, along highway
- References:
  - ITE Manual of Traffic Engineering Studies

164

Tool #15
Roadside Development

- Review of type, size, and number of development including:
  - Businesses, residences
  - Interference resulting from traffic disruptions
- Reviewed along a section of roadway



167

Tool #16
Roadside Obstructions

- Review roadside environment/hazards which:
  - Decreases sight distance
  - Restricts lateral movement
  - Potential hazards if vehicle leaves the roadway

168

Clear Zone Concept

"It is desirable to provide a roadside clear of hazardous objects or conditions ..."

172

173

TREE ROOSTER: Violet Hobaugh sits in a tree seeking to save it from being cut down in front of her Grantville home. Hobaugh said protesting Friday the state highway department's plans to remove the tree and install a sewer pipe. Hobaugh says the tree keeps vehicles from coming around a curve and crashing into her home.

Pennoni

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174

Treatment of Hazards in the Clear Zone

- Remove
- Redesign (i.e., make traversable)
- Relocate
- Reduce impact severity (e.g., breakaway)
- Shield
- Delineate

175

TABLE 3.1 (Cont'd)

[U.S. Customary Units]

DESIGN SPEED	DESIGN ADT	FORESLOPES			BACKSLOPES		
		1V:6H of Fixture	1V:5H TO 1V:4H	1V:3H	1V:3H	1V:5H TO 1V:4H	1V:6H or Flatter
40 mph or less	UNDER 750	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10
	750 – 1500	10 – 12	12 – 14	**	10 – 12	10 – 12	10 – 12
	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14
	OVER 6000	14 – 16	16 – 18	**	14 – 16	14 – 16	14 – 16
45–50 mph	UNDER 750	10 – 12	12 – 14	**	8 – 10	8 – 10	10 – 12
	750 – 1500	12 – 14	16 – 20	**	10 – 12	12 – 14	14 – 16
	1500 – 6000	16 – 18	20 – 26	**	12 – 14	14 – 16	16 – 18
	OVER 6000	18 – 20	24 – 28	**	14 – 16	18 – 20	20 – 22
55 mph	UNDER 750	12 – 14	14 – 18	**	8 – 10	10 – 12	10 – 12
	750 – 1500	16 – 18	20 – 24	**	10 – 12	14 – 16	16 – 18
	1500 – 6000	20 – 22	24 – 30	**	14 – 16	16 – 18	20 – 22
	OVER 6000	22 – 24	26 – 32 *	**	16 – 18	20 – 22	22 – 24
60 mph	UNDER 750	16 – 18	20 – 24	**	10 – 12	12 – 14	14 – 16
	750 – 1500	20 – 24	26 – 32 *	**	12 – 14	16 – 18	20 – 22
	1500 – 6000	26 – 30	32 – 40 *	**	14 – 18	18 – 22	24 – 26
	OVER 6000	30 – 32 *	36 – 44 *	**	20 – 22	24 – 26	26 – 28
65–70 mph	UNDER 750	18 – 20	20 – 26	**	10 – 12	14 – 16	14 – 16
	750 – 1500	24 – 26	28 – 36 *	**	12 – 16	18 – 20	20 – 22
	1500 – 6000	28 – 32 *	34 – 42 *	**	16 – 20	22 – 24	26 – 28
	OVER 6000	30 – 34 *	38 – 46 *	**	22 – 24	26 – 30	28 – 30

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear-zone shown in Table 3.1. Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the foreslope parameters which may enter into determining a maximum desirable recovery area are illustrated in Figure 3.2.

176

Tool #17
School Route Plan

- Shows recommended travel paths of school children
- Developed by municipal and school officials
- Map with streets, school, existing traffic controls, established routes and crossings
- Take advantage of existing controls

177

Tool #18
Sight Distance

- "Maximum distance that a driver can see objects ..."
- Many types:
  - Intersection sight distance
  - Stopping sight distance
  - Passing sight distance

178

Intersection Sight Distance

- Maximum distance a stopped driver can see another vehicle approaching
- Also known as Corner Sight Distance

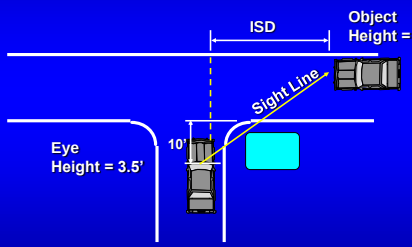
179

Intersection Sight Distance

- Criteria - **OPERATING**
  - Driver's eye height = 3.5'
  - Approaching vehicle = 3.5'
  - Driver located 10' from travel lane
- Criteria - **DESIGN**
  - Driver's eye height = 3.5'
  - Approaching vehicle = 3.5'
  - Driver located 14.5' from travel lane

180

Intersection Sight Distance



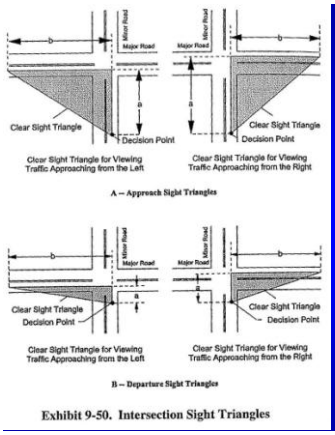


Exhibit 9-50. Intersection Sight Triangles

181

Intersection Sight Triangles from AASHTO Green Book

182

ISD Notes

- Left and right turns usually govern – not crossing maneuver
- *Most major road drivers should not need to reduce speed to less than 70% of their initial speed

186

Intersection Sight Distance

$ISD = 1.47 V_{major} T_g$

ISD = intersection sight distance (ft)

V_{major} = major road design speed (mph)

T_g = time gap for minor road vehicle to enter the major road

187

Left Turn from Stop Time Gap (T_g)

Design Vehicle	T_g (sec)
Passenger Car	7.5
Single-Unit Truck	9.5
Combination Truck	11.5

- Assumes no median, grades < 3%
- For multilane roads, add .5 sec per car or .7 sec for trucks per lane
- Add .2 sec per % grade over 3%

188

Intersection Sight Distance Left Turn from Stop

US Customary

Design speed (mph)	Stopping sight distance (ft)	Intersection sight distance for passenger cars	
		Calculated (ft)	Design (ft)
15	80	165.4	170
20	115	220.5	225
25	155	275.6	280
30	200	330.8	335
35	250	385.9	390
40	305	441.0	445
45	360	496.1	500
50	425	551.3	555
55	495	606.4	610
60	570	661.5	665
65	645	716.6	720
70	730	771.8	775
75	820	826.9	830
80	910	882.0	885

189

Right Turn from Stop Time Gap (T_g)

Design Vehicle	T_g (sec)
Passenger Car	6.5
Single-Unit Truck	8.5
Combination Truck	10.5

- Assumes no median, grades < 3%
- For multilane roads, add .5 sec per car or .7 sec for trucks per lane
- Add .2 sec per % grade over 3%

190

Intersection Sight Distance Right Turn from Stop

US Customary

Design speed (mph)	Stopping sight distance (ft)	Intersection sight distance for passenger cars	
		Calculated (ft)	Design (ft)
15	80	143.3	145
20	115	191.1	195
25	155	238.9	240
30	200	286.7	290
35	250	334.4	335
40	305	382.2	385
45	360	430.0	430
50	425	477.8	480
55	495	525.5	530
60	570	573.3	575
65	645	621.1	625
70	730	668.9	670
75	820	716.6	720
80	910	764.4	765

191

Is the tree trimming at this corner adequate?

Trees trimmed to 4 feet high

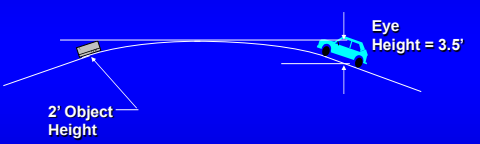
192

Stopping Sight Distance

- Length of highway over which an object is visible to the driver at all times
  - Driver's eye height = 3.5'
  - Height of object = 2.0'

193

Stopping Sight Distance



194

Stopping Sight Distance

$SSD = 1.47VT + V^2 / [30*(f+g)]$

SSD = stopping sight distance (ft)
V = 85th %ile speed (mph)
T = driver perception time (assume 2.5 sec)
f = coefficient of friction for wet pavement
g = % grade of roadway

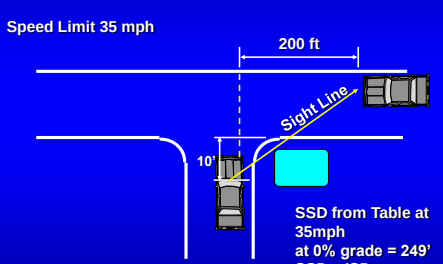
195

Minimum Stopping Sight Distance (feet)

85th Percentile Speed (mph)	Coefficient of friction	Grade -10%	Grade -5%	Grade 0%	Grade 5%	Grade 10%
25	0.38	166	155	147	140	135
30	0.35	230	210	196	185	177
35	0.34	299	269	249	233	221
40	0.32	389	345	314	291	274
45	0.31	487	425	383	353	330
50	0.30	600	517	462	422	392
55	0.30	706	605	538	490	454
60	0.29	852	721	634	573	528

196

Critical Case: SSD > ISD



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Tool #19 Speed Data

- Types of speed data:
  - Speed limit
  - Spot speed
  - Safe-running speed
  - Recommended speed on curves
  - Design speed

198

Spot Speed

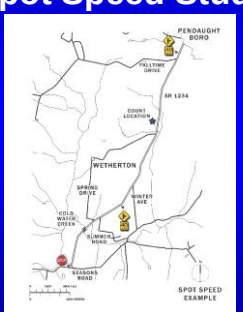
- Instantaneous measurement by an electronic or electrical device:
  - Radar
  - Vascar
- 85th Percentile speed
- Average speed

199

In Class Example: Spot Speed Study

200

In Class Example: Spot Speed Study



201

Example: Spot Speed Study

- Determine 85th percentile speed based on speed distribution study data sheet.
- What is 85th percentile speed?

202

Massachusetts Speed Limits (Section 11A-8)

- Municipality complete studies and submit to Department
- Department reviews and approves
- Municipality adopts
- Municipality, Department, Registry certify and Approve
- Certified regulation sent to Municipality
- Install Signs

203

Guidelines for Spot Speed Studies

- Urban Districts:
  - 0.5 mile intervals
  - traffic or roadway features change
  - midblock locations
- Rural Districts:
  - 2 mile intervals
  - tangent section of roadway

204

Guidelines for Spot Speed Studies (cont'd)

- 100 observations minimum
  - 50 observations on Low Volume Roads
- Randomly selected
- % trucks sampled = % truck on road
- Avoid high speed vehicles
- Taken during non-peak periods
- Taken during good weather conditions

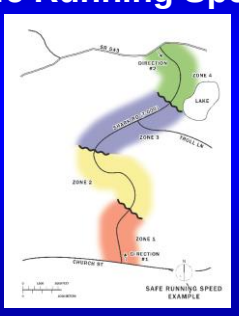
205

Safe Running Speed

- Determined by taking a minimum of 5 test runs in each direction
- Average value of test speeds
- Assumes a "reasonable and prudent" driver

206

In Class Example: Safe Running Speed



207

In Class Example: Safe Running Speed

Test Run Number	Speed (MPH)							
	Church Street to First Curve		*Through Curves*		*Straight Stretch Up to Lake*		*Lake to PA 543*	
	Direction #1	Direction #2	Direction #1	Direction #2	Direction #1	Direction #2	Direction #1	Direction #2
1	34	32	22	26	38	40	37	40
2	32	33	23	25	40	42	35	39
3	27	30	20	25	34	40	34	37
4	30	30	20	25	36	38	34	35
5	29	30	22	25	34	38	34	36
Average	30.4	31.0	21.4	25.2	36.4	39.6	34.8	37.4
Overall Average =		32.0						

208

Recommended Speed on Curves

- Ball-bank indicator
- Trial runs :speed in 5 mph increments
- Safe Speed = highest speed not exceeding table values

Speed (mph)	Ball-bank indicator (degrees)
20 or less	16
25 and 30	14
35 or more	12

209

Design Speed

- The selected speed used to determine the values for different geometric features
- Used for design:
  - Radius of curves
  - Superelevation
  - Cross-section
  - Sight distance

210

Element #18
Structural Analysis

- Review of safety of bridge by a Qualified Engineer
- Determination of load capacity rating

211

Structural Analysis

- Considers:
  - Type of vehicles
  - Weight
  - Speed
  - Volume of traffic
  - Soundness of structure

212

Tool #21
Traffic Calming

- Institute of Transportation Engineers (ITE) Defines Traffic Calming as:
  - *The combination of mostly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.*

213

Is Traffic Calming Appropriate?

- Study and Approval Process is the key
- What is a community's threshold?
- Education, Enforcement, and Engineering
- Local and Collectors streets
- Some arterials
  - "downtown" areas
  - posted speeds under 40

214

A "Shed Full of Devices"

215

Unconventional Traffic Calming

216

Four Categories of Devices

- Vertical Deflection
  - Primarily used for speed control
  - Example: Speed Humps
- Horizontal Deflection
  - Horizontal shift in the roadway
  - Narrow the width of the travel lane
  - Primarily used for speed control
  - Example: Traffic circles

217

Four Categories of Devices

- Physical Obstruction
  - Prevent particular vehicle movements
  - Primarily used for volume control
  - Example: Diverters
- Sign and Pavement Markings
  - Require enforcement
  - Be careful with these (standards)
  - Example: Transverse Markings

218

Speed Humps and Speed Tables

- Create a vertical acceleration difference for motor vehicles
- Raised pavement constructed in, on, or across existing roadway.
- Used for motor vehicle speed reduction
- Guidelines exist for this particular device (ITE)

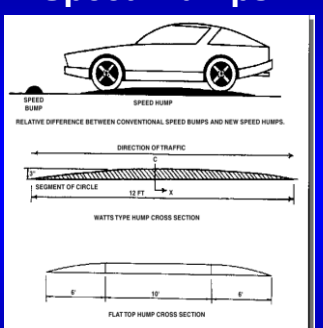
219

Speed Hump Types

- 12' speed hump - ITE, PA Publication 383
- 14' speed hump - Portland, Oregon
- 22' speed table - Seminole County, Florida
- 22' Split speed hump - Portland, Oregon

220

Speed Humps



221

Appropriate Location

- 12' Hump
  - ADT less than 3,500
  - Posted speed of 30 MPH or less
  - local streets
- 22' Table
  - ADT up to 6,500
  - Collector roads
  - Allowed on emergency response routes

Fundamentals of Analyzing and Solving Local Traffic Problems

222

Speed Reductions

- 12' Hump designed to slow vehicles:
  - 15-20 MPH at each hump
  - 25-30 MPH between humps
  - Avg. 8 MPH and 18% volume reduction
- 22' Table designed to slow vehicles:
  - 25-30 MPH at each hump
  - 35 MPH between humps
  - Avg. 6.5 MPH and 12% volume reduction

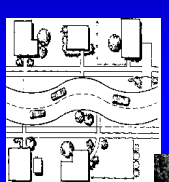
223

Other Considerations

- Most effective if used in a series
  - 250 - 600 ft. apart is recommended
- Do not place on curves with a radius less than 300 feet
- Do not use on greater than an 8% grade
- Not recommended unless curbing in place
- REMEMBER SIGNS and PAVEMENT MARKINGS

228

Chicanes



Montgomery County, MD

Alachua, FL

229

Traffic Diverters

- May be "full" or "semi" diverters
- Typically used for volume problems
- Help discourage cut-through traffic in neighborhoods

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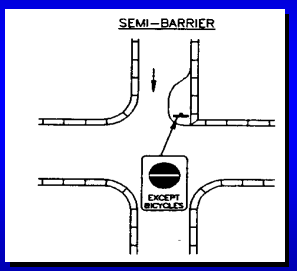
Semi-Traffic Diverter



231

232

Semi-Diverters

- Create a one-way roadway at intersection while 2-way traffic remains for the rest of the roadway
- Use on local streets, up to 3,500 ADT
- Document a cut-through problem
- May reduce from 40-60% of volume
- Minimal speed reduction
- May need some enforcement

233

Traffic Diverter

234

Full Traffic Diverter

- Use on local streets, up to 3,500 ADT
- Remember your signs and pavement markings
- Emergency response concerns

237

Transverse Markings

- Double thick thermoplastic pavement markings
- 5 transverse, 6 inch wide strips
- Installed 2 feet on center
- Repeated every 100 feet
- Estimated speed reductions of 1 to 3 MPH

238

239

Transverse Markings

- School zones, in advance of curves,
- Some noise generation
  - resident issues
  - vehicle vibration as well
- NOT Rumble Strips
  - Alert motorists to a controlled stop
  - potentially hazardous condition
  - Noise is incompatible with residential areas

240

Issues Related to Traffic Calming Devices

- Proper signing and markings
- Funding
- Emergency Service Vehicles
- Maintenance
- Snow Removal

241

242

Study and Approval Process

TAP

243

Traffic Calming Policy

- A policy which establishes the procedures to be followed in order to implement traffic calming measures in a municipality
- Ranking system to help the municipality identify, prioritize, implement, and evaluate traffic calming projects

244

Components

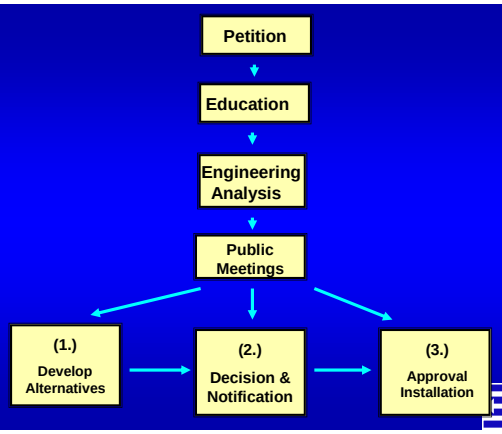
- Establish objectives and policy
- Establish ranking system
- Identify problem/issue
- Develop alternative solutions
- Select an appropriate plan of action
- Traffic calming implementation
- Program review

245

Importance of a Policy and Ranking System

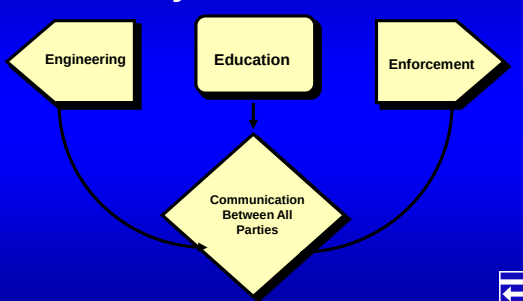
- Sets minimum standards
- Sets reasonable priorities
- Raises issues
- "The tie that binds" (brings residents, officials, etc. together on the topic)

246



247

Keys to Success



248

Legal Issues and Liability Surrounding Traffic Calming

249

Areas of Liability

- Legal authority
- Tort Liability
- Loss of access
- Failure to act

250

Damage Claims

- More common than lawsuits, but still rare
- Seattle: 3 paid claims in 15 years, all less than $1,000
- Signage, Construction, Design

251

Avoiding Litigation

Process	Document
Process	Document
Process	Document

252

Avoiding Litigation

- Confirm authority
- Hire a professional
- Establish program plan
- Document procedure
- Follow standard design practices
- Provide adequate signing and markings
- Inspect construction

253

Other Issues to Consider

- Emergency Vehicles
  - Police, Ambulance, Fire, & Snow
  - Access Considerations
- Unfamiliarity of Drivers
- Increased Maintenance

254

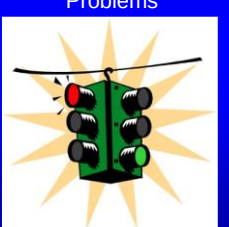
Traffic Calming

- Not the “Cure-all” for every traffic problem
- Mostly applicable to local streets
- Solves speeding and cut-through traffic problems on local streets
- Improves residential quality of life

255

Tool #22: Traffic Signals

Signals – They Solve Problems, They Create Problems



256

Benefits of Signals

Properly warranted and installed signals:

- Increase traffic-handling capacity over 4-way stops
- Enhance the orderly movement of traffic
- Reduce the frequency of *left turn, straight* and *right angle* crashes
- Regulate speed along a route
- Permit other traffic and pedestrians to cross

257

Problems Caused by Signals

Unwarranted or improperly installed signals:

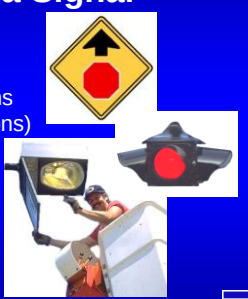
- Create excessive delays
- Encourage a disregard for traffic signals
- Encourage the use of alternate routes
- Increase the likelihood of *rear end* collisions

258

Options to Consider Before Installing a Signal

To improve visibility:

- Advance warning signs (with or without beacons)
- Relocating stop lines
- Flashing red beacon
- Roadway lighting

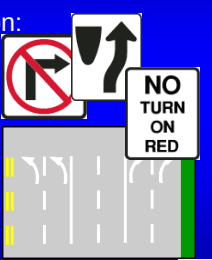


259

Options to Consider Before Installing a Signal

To improve traffic operation:

- Additional lanes
- Revised geometrics
- Restricted turning movements
- Roundabout

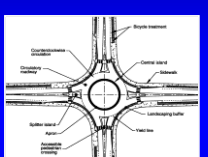


260

Options to Consider Before Installing a Signal

To reduce speeds:

- Traffic calming measures
- Targeted enforcement
- Roundabout



261

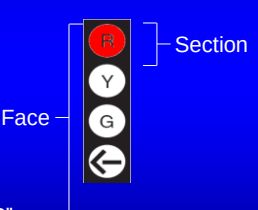
Signal Terminology

Signal Face

- Contains 3, 4, or 5 sections

Signal Section

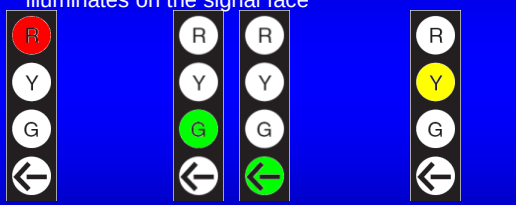
- Each light is a section
- Must be red, green, or yellow
- Modern sections are 12" diameter.



262

Signal Terminology

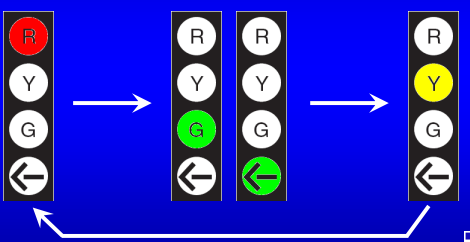
- **Interval** - Period of time that one color illuminates on the signal face



263

Signal Terminology

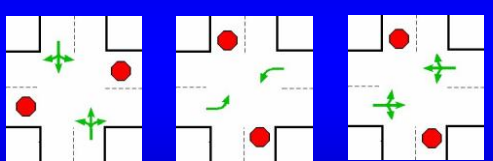
- **Cycle** - Series of all intervals



264

Signal Terminology

- **Phase** - Defined by traffic movement allowed



265

Signal Timing

- Fixed signal
  - Operates independent of time of day or traffic patterns
- Actuated signal
  - Changes based on time of day or traffic pattern
- Coordinated signal
  - Operates within a series of synchronized signals

266

Signal Timing

- Cycle length: 60 to 120 seconds
- Green phase: 5 to 40 seconds
- Yellow phase: 3 to 6 seconds
- All red phase: 1.5 to 6 seconds

267

Signals Warrants

- 8 total warrants
- Only need to meet 1 to be *warranted*
- A warrant does not require an installation, only provides substantial evidence that conditions exist
  - Studies should prove safety and operation will improve
  - *Better have good reason not to install a signal that is warranted.

268

Signal Warrants: Where to Start

- Manual on Uniform Traffic Control Devices (MUTCD) Part 4
- Get an engineer involved for a signal warrant

269

Traffic Signal Warrants

1. Eight-hour vehicular volume
2. Four-hour vehicular volume
3. Peak Hour
4. Pedestrian volume

270

Traffic Signal Warrants

5. School crossing
6. Coordinated signal system
7. Crash experience
8. Roadway Network

290

Just for Fun

291

Tool #23 Traffic Volumes

- Record of number of vehicles:
  - passing a point
  - entering an intersection
  - using a particular facility
- Reference: ITE Manual of Transportation Engineering Studies

Fundamentals of Analyzing and Solving Local Traffic Problems

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Traffic Volumes

- Average Daily Traffic (ADT)
- Peak Hour Traffic
- Turning Movements
- Kinds and Classes

296

Peak Hour Traffic

- Highest # of vehicles passing a section of road during 60 consecutive minutes
- Peak Hour counts:
  - AM Peak (typical 0700-0900)
  - PM Peak (typical 1600-1800)

297

Turning Movements

- Typically manually counted
- ADT or peak-hour volumes categorized by:
  - # left turns
  - # thru traffic
  - # right turns

298

Kinds and Classes

- Typically automatically counted
  - Type of vehicle
  - Weight of vehicle
  - Number of axles

302

Tool #24
Type of Highway

- Classification of highway
- Examples- both Urban and Rural:
  - Local Roads
  - Collectors
  - Arterials
  - Expressways
  - Freeways

Fundamentals of Analyzing and Solving Local Traffic Problems

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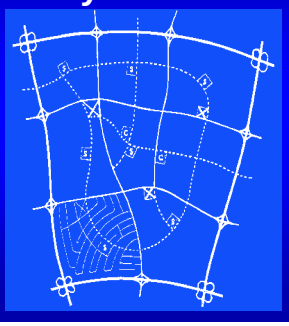
Roadway Classification



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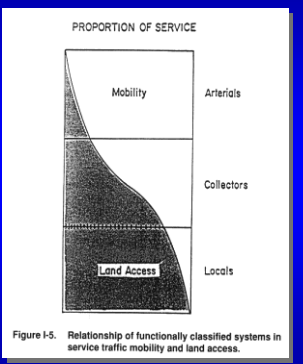


Figure I-5. Relationship of functionally classified systems in service traffic mobility and land access.

Service varies based on the roadway facility type:

Local Streets typically promote greater access

305

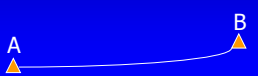
Tool #25
Intersection Delay

- Involves the counting of vehicles stopped in the intersection approach at successive 15 sec. intervals
- Output from data sheet
  - Total stopped-time delay
  - Average stopped-time delay
  - Percentage of vehicles stopped
- References:
  - ITE Manual of Transportation Engineering Studies
  - FHWA A Technique for Measurement of Delay at Intersections

306

Tool #26
Travel Time and Delay

- Travel Time



By traveling several times in a car from A to B, a person notes down the time taken in each run and then comes up with a statistical average of Travel Time.

307

Travel Time and Delay

- Delay

Delay = Actual travel time - Expected travel time

308

Calculation of Delay

- Travel time delay
  - Actual travel time data collected by traveling in a car through the stretch of the road under study.
  - Expected travel time calculated from the distance and average speed.
  - Travel time delay calculated from the difference between actual travel time and expected travel time.
- Stopped time data for the vehicular speed of 0 to 5 mph.

Fundamentals of Analyzing and Solving Local Traffic Problems

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Part III: Applications

Guidelines for Engineering and Traffic Studies

Study Element Number	Study Elements																					
	Crash Analysis	Acceleration Lane	Alternate Route	Angle Parking Restrictions	Arrival & Departure Time Studies	Capacity Analysis	Gap Study for School Children	Geometric Review	Parallel Streets	Part Experience	Placement Analysis	Pedestrian Volumes	Roadside Development	Roadside Observations	School Route Plan	Sight Distance	Speed Data	Structural Analysis	Traffic Signals	Traffic Volumes	Type of Highway	Intersection Delay
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 Parking, Stopping or Standing Restriction	X					X		X								X				X		
2 Angle Parking	X			X		X		X				X				X	X			X		
3 Speed Limits	X															X	X					
4 School Zone Speed Limits					X			X				X			X							
5 Special Speeds on Bridges and Elevated Structures	X					X												X		X		
6 Hazardous-grade Speed Limits	X							X					X	X		X	X			X		
7 One-way Streets	X					X		X	X								X			X		
8 Through Highway	X							X				X				X	X			X		
9 Stop or Yield Control at Intersections	X	X						X				X				X	X			X		
10 Multi-way Stop Control at Intersections	X	X						X				X				X	X			X		
11 Stop or Yield Control at locations other than Intersections	X	X						X								X	X			X		
12 No-passing Zones	X					X		X					X			X	X			X		
13 Traffic-control Signals	X					X	X					X					X			X		X
14 Turn Restrictions	X					X						X				X	X			X		
15 No-turn-on-red Restrictions	X							X				X				X	X		X	X		
16 Restrictions as to Weight or Size Based on Condition of Highway or Bridge								X		X	X							X	X	X		
17 Restrictions as to Weight, Size, Kind or Class or Type of Load, Based on Traffic Conditions	X							X									X			X		
18 Designations of Alternate Routes for Restricted Vehicles	X		X					X			X							X		X		
19 Retrieval of Traffic Hazards	X							X								X	X			X		
20 Special Events - Processions, Assemblages and Special Activities	X					X				X										X	X	
21 Engine Retarder Restriction	X							X								X	X			X		
22 Stop Except Right Turn	X							X								X				X		
23 Hazardous Walking Route	X				X		X	X				X			X	X	X			X		

311

Guidelines for Miscellaneous Traffic Studies

Study Element Number	Study Elements																					
	Crash Analysis	Acceleration Lane	Alternate Route	Angle Parking Restrictions	Arrival & Departure Time Studies	Capacity Analysis	Gap Study for School Children	Geometric Review	Parallel Streets	Part Experience	Placement Analysis	Pedestrian Volumes	Roadside Development	Roadside Observations	School Route Plan	Sight Distance	Speed Data	Structural Analysis	Traffic Signals	Traffic Volumes	Type of Highway	Intersection Delay
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
20 Mid-block Crosswalks	X							X								X	X			X		
21 Advance Warning Signs	X							X									X			X		
22 Ball-bank of Curves	X							X									X					
23 Sight Distance	X							X									X			X		
26 School Bus Stop Ahead	X							X								X	X					
29 Minors	X							X								X	X			X		

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Part III: Applications

- Stop signs
- Multiway stop signs
- Speed limits
- Traffic calming
- Turn restrictions
- One way streets

313

Part III: Applications

- Stopping standing and parking restrictions
- No turn on red restrictions
- Removal of traffic hazards
- Special events

314

Stop Signs

03 *YIELD or STOP signs should be used at an intersection if one or more of the following conditions exist:*

A. An intersection of a less important road with a main road where application of the normal right-of-way rule would not be expected to provide reasonable compliance with the law;

B. A street entering a designated through highway or street; and/or

C. An unsignalized intersection in a signalized area.

04 *In addition, the use of YIELD or STOP signs should be considered at the intersection of two minor streets or local roads where the intersection has more than three approaches and where one or more of the following conditions exist:*

A. The combined vehicular, bicycle, and pedestrian volume entering the intersection from all approaches averages more than 2,000 units per day;

B. The ability to see conflicting traffic on an approach is not sufficient to allow a road user to stop or yield in compliance with the normal right-of-way rule if such stopping or yielding is necessary; and/or

C. Crash records indicate that five or more crashes that involve the failure to yield the right-of-way at the intersection under the normal right-of-way rule have been reported within a 3-year period, or that three or more such crashes have been reported within a 2-year period.

05 *YIELD or STOP signs should not be used for speed control.*

Support:

06 Section 2B.07 contains provisions regarding the application of multi-way STOP control at an intersection.

Guidance:

07 *Once the decision has been made to control an intersection, the decision regarding the appropriate roadway to control should be based on engineering judgment. In most cases, the roadway carrying the lowest volume of traffic should be controlled.*

08 *A YIELD or STOP sign should not be installed on the higher volume roadway unless justified by an engineering study.*

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Massachusetts Regulations for Stop Signs (11A-4)

- "It [Stop sign] is not intended nor SHALL it be used for control of speed, traffic calming…"
- "To ensure uniformity in stop sign studies and recommendations, the warrants as provided in the 2003 MUTCD, Section 2B.05 will govern…"

316

Stop Signs

- What if volumes are about equal?
  - Control direction that conflicts most with pedestrian or school route activity
  - Control direction that has obscured vision, dips, bumps, that require lower operating speeds
  - Control direction with best sight distance
  - Multiway stop?

317

MUTCD Stop Sign Warrants (2B.06)

Engineering judgment indicates:

A. Volumes on through street exceed 6,000 vpd
B. Restricted sight distance
C. 3 or more crashes in a 12 month period or 5 in 2 years of a type susceptable to correction

318

Through Highway Warrants

- MA Amendments
  - Through way carries a higher volume of traffic Density should allow for constant flow.
  - Traffic movements should be relatively fast and consistent
  - Should not parallel another Through Way
  - Stop rule application on 80% of the route

319

Tools Utilized

- Crash Analysis
- Geometric Review
- Past Experience
- Roadside Obstructions
- Sight Distance
- Speed Data
- Traffic Volumes
- Type of Highway

320

Example: Stop Sign

- Issue: angle crashes with cars pulling out from side road

321

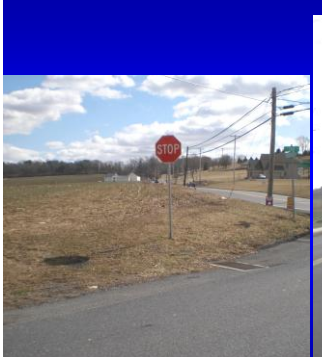
Example: Stop Sign

- Potential solutions?

322

Example: Stop Sign

324



325

Multiway Stop Signs

- MUTCD Sections 2B.04 – **2B.07**
- To be used as a SAFETY measure when volumes are about equal
- NOT to be used for speed control

326

Multiway Stop Signs

- Review Information in MUTCD

Section 2B.07 Multi-Way Stop Applications

Support:

01 Multi-way stop control can be useful as a safety measure at intersections if certain traffic conditions exist. Safety concerns associated with multi-way stops include pedestrians, bicyclists, and all road users expecting other road users to stop. Multi-way stop control is used where the volume of traffic on the intersecting roads is approximately equal.

02 The restrictions on the use of STOP signs described in Section 2B.04 also apply to multi-way stop applications.

327

MUTCD Multiway Stop Sign Warrants

A. Traffic signal warranted

B. Crash analysis: 5 or more crashes in a 12 month period of a type susceptible to correction by multiway stops
   - Right and left turn collisions
   - Right angle collisions

328

MUTCD Multiway Stop Sign Warrants

C. Minimum Traffic Volume:
   1. Total HOURLY traffic volume entering intersection on the MAJOR approaches averages at least 300 vehicles for any 8 hours of a day; AND
   2. Combined hourly traffic and pedestrian volume from the MINOR street approaches averages at least 200 for the same 8 hours and average 30 sec. delay

329

MUTCD Multiway Stop Sign Warrants

C. Minimum Traffic Volume (cont.):
   3. If the 85th percentile approach speed of the major street traffic is greater than 40 mph, then the minimum traffic volume warrants are 70%

D. Warrants B, C1 and C2 are satisfied to 80%

330

Unwarranted Multiway Stops

- Over 20 research papers conclude that stop signs are ineffective for speed control.
- May cause crashes they are intended to prevent
- Breed disrespect for other necessary stop signs and other control devices

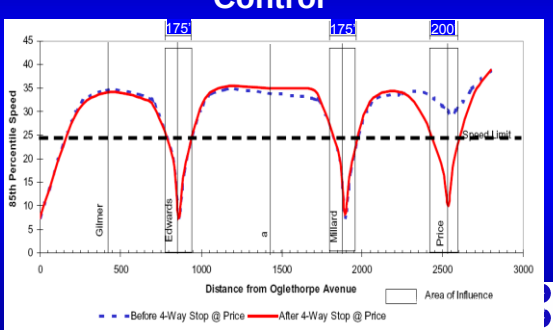
331

Unwarranted Multiway Stops

- Waste fuel
- Contribute to air and noise pollution
- Create unnecessary delay

332

Speed Before & After Installation of 4-way Stop Control



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The Cost of 4-Way Stops

- Each unwarranted 4-way stop sign costs society $200,000 each year
- Assuming:
  - Intersection volume of 8,000 vehicles per day
  - Delay cost of $.03401/Stop
  - Operating cost of $.04291/Stop
- Cited from: *Neighborhood Traffic Management in the Dallas/Fort Worth Area* by Wiersig & Van Winkle, published by ITE Compendium of Technical Papers, 1985

334

Massachusetts Regulations for Stop Signs (11A-4)

- "Multi-way Stop signs must meet the warrant criteria outlined in Section 2B.07 of the 2003 MUTCD."

335

Other Multiway Stop Sign Considerations

1. Inclusion of non-reportable crashes?
2. Multiway stop applications should not be used because of limited available corner sight distance unless there is no practical method of improving the sight distance or reducing the speed limit to satisfy the minimum corner sight distance values.

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In Class Example: Multiway Stop

337

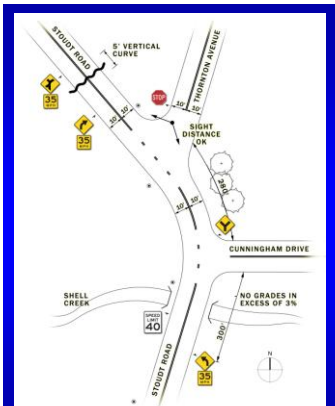
Example: Multi-way Stop Signs

Looking North

Looking South

Looking West at the stop sign

338



Example: Multi-way Stop Signs

Geometric Review

- Measure lane width
- Measure vertical curves
- Measure horizontal curves
- Note super-elevation
- Document all signage
- Document all hazards (utility poles, end walls, trees, etc.)
- Check sight distance

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Example: Multi-way Stop Signs

Intersection Data

- Posted Speed Limit = 40 MPH
- 85th Percentile Speed = 46 MPH
- Three (3) crashes correctable by multi-way stop sign in the 12 month period
- Total intersection ADT volume = 6966 vehicles
- No signal warrant study completed
- Traffic volumes, sight distance shown on next slides

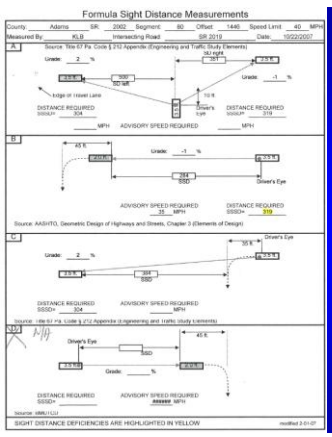
340

Time	Stoudt Rd (NB + SB)	Thorton Avenue (WB)	Meets Warrants?
1:00	28	12	
2:00	28	11	
3:00	24	4	
4:00	16	8	
5:00	44	11	
6:00	180	42	
7:00	308	74	
8:00	544	164	
9:00	484	193	
10:00	340	127	
11:00	204	100	
12:00	270	137	
13:00	348	188	
14:00	232	113	
15:00	352	137	
16:00	314	156	
17:00	368	129	
18:00	316	114	
19:00	252	104	
20:00	164	105	
21:00	122	110	
22:00	130	88	

Example: Multi-way Stop Signs

Traffic Volume Data

341



Example: Multi-way Stop Signs

Intersection Sight Distance

342

Sample Improvements

343

Speed Limits

- MUTCD Sections 2B.13 – 2B.17
- You MUST work with the Mass Highway and Registry
- Learn about your statutory restrictions

344

Massachusetts Speed Limits (Section 11A-8)

- Municipality complete studies and submit to Department
- Department reviews and approves
- Municipality adopts
- Municipality, Department, Registry certify and Approve
- Certified regulation sent to Municipality
- Install Signs

Fundamentals of Analyzing and Solving Local Traffic Problems

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Speed Limit

- Review Information in MUTCD

Section 2B.13 Speed Limit Sign (R2-1)

Standard:

01 Speed zones (other than statutory speed limits) shall only be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices. The engineering study shall include an analysis of the current speed distribution of free-flowing vehicles.

02 The Speed Limit (R2-1) sign (see Figure 2B-3) shall display the limit established by law, ordinance, regulation, or as adopted by the authorized agency based on the engineering study. The speed limits displayed shall be in multiples of 5 mph.

03 Speed Limit (R2-1) signs, indicating speed limits for which posting is required by law, shall be located at the points of change from one speed limit to another.

346

Other Speed Limits

- Normally established within 5 MPH of the average 85th percentile speed or safe running speed
- May be reduced by 10 mph for:
  - Insufficient stopping sight distance
  - ISD on side roads < SSD on through road
  - Crashes
    - High crash rate
    - Majority are related to excessive speed

347

In-Class Example: Safe Speeds on Curves

348

Existing Conditions

349

Curve Speed Study Example

- The curve has a crash problem because cars are traveling too fast through the curve.
- The posted speed limit is 40 mph for the roadway.
- There is currently an advanced warning sign, but no advisory speed plaque.

350

Curve Speed Study Example

- What should the advisory speed be based on the ball bank readings?

Speed (mph)	*Ball-bank indicator (degrees)*
10	8
15	11
20	13
25	14
30	15

Advisory Speed (mph)	*Ball-bank indicator (degrees)*
20 or less	16
25 and 30	14
35 or more	12

351

Install larger curve sign with object markers

After Improvements

352

Install delineators

After Improvements

353

Advanced Warning Sign Placement (MUTCD Table 2C-4)

Posted or 85th-Percentile Speed	Advance Placement Distance[1]								
	Condition A: Speed reduction and lane changing in heavy traffic[2]	Condition B: Deceleration to the listed advisory speed (mph) for the condition							
		0[3]	10[4]	20[4]	30[4]	40[4]	50[4]	60[4]	70[4]
20 mph	225 ft	100 ft[5]	N/A[5]	—	—	—	—	—	—
25 mph	325 ft	100 ft[5]	N/A[5]	N/A[5]	—	—	—	—	—
30 mph	460 ft	100 ft[5]	N/A[5]	N/A[5]	—	—	—	—	—
35 mph	565 ft	100 ft[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—
40 mph	670 ft	125 ft	100 ft[5]	100 ft[5]	N/A[5]	—	—	—	—
45 mph	775 ft	175 ft	125 ft	100 ft[5]	100 ft[5]	N/A[5]	—	—	—
50 mph	885 ft	250 ft	200 ft	175 ft	125 ft	100 ft[5]	—	—	—
55 mph	990 ft	325 ft	275 ft	225 ft	200 ft	125 ft	N/A[5]	—	—
60 mph	1,100 ft	400 ft	350 ft	325 ft	275 ft	200 ft	100 ft[5]	—	—
65 mph	1,200 ft	475 ft	450 ft	400 ft	350 ft	275 ft	200 ft	100 ft[5]	—
70 mph	1,250 ft	550 ft	525 ft	500 ft	450 ft	375 ft	275 ft	150 ft	—
75 mph	1,350 ft	650 ft	625 ft	600 ft	550 ft	475 ft	375 ft	250 ft	100 ft[5]

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Horizontal Alignment Sign Selection (MUTCD Table 2C-5)

Type of Horizontal Alignment Sign	Difference Between Speed Limit and Advisory Speed				
	5 mph	10 mph	15 mph	20 mph	25 mph or more
Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), Winding Road (W1-5), and Combination Horizontal Alignment/Intersection (W10-1) (see Section 2C.07 to determine which sign to use)	Recommended	Required	Required	Required	Required
Advisory Speed Plaque (W13-1P)	Recommended	Required	Required	Required	Required
Chevrons (W1-8) and/or One Direction Large Arrow (W1-6)	Optional	Recommended	Required	Required	Required
Exit Speed (W13-2) and Ramp Speed (W13-3) on exit ramp	Optional	Optional	Recommended	Required	Required

Note: Required means that the sign and/or plaque shall be used, recommended means that the sign and/or plaque should be used, and optional means that the sign and/or plaque may be used.

See Section 2C.06 for roadways with less than 1,000 ADT.

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Turn Restrictions

- MUTCD Section 2B.18

357

Turn Restrictions

- Review Information in MUTCD

Section 2B.18 Movement Prohibition Signs (R3-1 through R3-4, R3-18, and R3-27)

Standard:

01 **Except as provided in Paragraphs 11 and 13, where specific movements are prohibited, Movement Prohibition signs shall be installed.**

Guidance:

02 *Movement Prohibition signs should be placed where they will be most easily seen by road users who might be intending to make the movement.*

03 *If No Right Turn (R3-1) signs (see Figure 2B-4) are used, at least one should be placed either over the roadway or at a right-hand corner of the intersection.*

04 *If No Left Turn (R3-2) signs (see Figure 2B-4) are used, at least one should be placed over the roadway, at the far left-hand corner of the intersection, on a median, or in conjunction with the STOP sign or YIELD sign located on the near right-hand corner.*

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Sample Turn Restriction Warrants

1. Crash analysis: 10 crashes in the last 3 years OR 5 crashes during a 12 month period in the last 3 years attributed to the movement
2. Capacity analysis: Turning or crossing vehicles causing unreasonable delay or potential crashes
3. Field Review: Significant conflict between movement and other vehicles or pedestrians

359

Turn Restriction Warrants

4. Field Review: Turn delays the platoon of vehicles through a progressive signal system
5. Field Review: Geometric design or CSD does not allow for the movement
6. Study: Turning movement frequently being made by through traffic onto a residential street to avoid downstream congestion.

360

Example Problem

Should left turns be restricted?

361

Example Problem

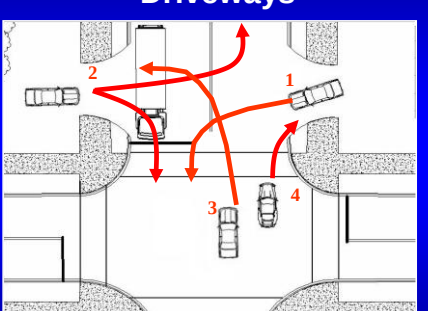
- Posted Speed Limit = 55 mph
- Safe Running Speed thru curve/intersection = 45 mph
- Left turn sight distance is less than stopping sight distance
- Should northbound left turn be restricted?

362

Intersection Improvements

363

Example: Turn Restrictions for Driveways



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One Way Streets

- MUTCD Sections 2B.40

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One Way Streets

- Review Information in MUTCD

Section 2B.40 ONE WAY Signs (R6-1, R6-2)

Standard:

01 **Except as provided in Paragraph 6, the ONE WAY (R6-1 or R6-2) sign (see Figure 2B-13) shall be used to indicate streets or roadways upon which vehicular traffic is allowed to travel in one direction only.**

02 **ONE WAY signs shall be placed parallel to the one-way street at all alleys and roadways that intersect one-way roadways as shown in Figure 2B-14.**

03 **At an intersection with a divided highway that has a median width at the intersection itself of 30 feet or more, ONE WAY signs shall be placed, visible to each crossroad approach, on the near right and far left corners of each intersection with the directional roadways (see Figure 2B-15).**

04 **At an intersection with a divided highway that has a median width at the intersection itself of less than 30 feet, Keep Right (R4-7) signs and/or ONE WAY signs shall be installed (see Figures 2B-16 and 2B-17). If Keep Right signs are installed, they shall be placed as close as practical to the approach ends of the medians and shall be visible to traffic on the divided highway and each crossroad approach. If ONE WAY signs are installed, they shall be placed on the near right and far left corners of the intersection and shall be visible to each crossroad approach.**

Option:

05 **At an intersection with a divided highway that has a median width at the intersection itself of less than 30 feet, ONE WAY signs may also be placed on the far right corner of the intersection as shown in Figures 2B-16 and 2B-17.**

06 ONE WAY signs may be omitted on the one-way roadways of divided highways, where the design of interchanges indicates the direction of traffic on the separate roadways.

369

Massachusetts Regulations (11A-3)

- "The streets or portions of streets in municipalities where parking is to be prohibited, restricted, or otherwise regulated are matters generally left for the determination of the local rulemaking body. This also applies to one-way streets and turning movement restrictions."

370

Sample One-Way Street Warrants

All criteria must be satisfied:

1. Traffic flow accommodated in both directions. If possible, one-way couplets should be formed
2. Reasonable entrance and exit points from one-way system
3. Satisfactory transition to and from two-way operation

371

One-Way Streets

4. Reduction of intersection delays
6. Existing bus routes can be accommodated
7. Emergency vehicles can easily reach their destination

373

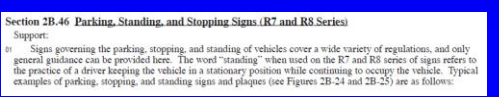
Stopping, standing and parking restrictions

- MUTCD Sections 2B.46 – 2B.49
- Restrictions may include:
  - General stopping, standing and parking
  - Angle parking
  - Parking meters
  - Prohibition of kinds and classes
  - Parking reserved for persons with disabilities
  - Miscellaneous restrictions
  - Double Parking

374

General Parking Restrictions

- Review Information in MUTCD



Section 2B.46 Parking, Standing, and Stopping Signs (R7 and R8 Series)

Support:

01 Signs governing the parking, stopping, and standing of vehicles cover a wide variety of regulations, and only general guidance can be provided here. The word "standing" when used on the R7 and R8 series of signs refers to the practice of a driver keeping the vehicle in a stationary position while continuing to occupy the vehicle. Typical examples of parking, stopping, and standing signs and plaques (see Figures 2B-24 and 2B-25) are as follows:

375

Statutory Parking Restrictions

- Sample MA Standard Municipal Traffic Code
  - Within 10' of a fire hydrant
  - Within 20' of an intersecting way, except alleys
  - Within 25' of the nearest rail of a RR crossing when there are no gates
  - Several others
- No study is necessary
- Often supplemented with curb markings

376

Other General Parking Restriction Warrants

1. Distance from centerline to edge of roadway
   - Major arterial: < 19 ft.
   - Other roadway: < 18ft.
2. Vehicles must yield to one another when vehicle is parked along side of roadway
3. Area needed for capacity

377

Other General Parking Restriction Warrants

4. Intersection sight distance is less than minimum SSD for drivers on through road
5. Crash analysis: At least 3 crashes during 3 yr. period attributed to parking
6. Official bus stop
7. Area adjacent or opposite a fire station driveway

378

Other General Parking Restriction Warrants

8. Width of shoulder inadequate to allow a vehicle to park completely off the roadway
9. Roadways with 3 or more lanes and speed limits 40 MPH or above, allow vehicle to use shoulder as a clear recovery area

379

In Class Example: Parking Restriction

380

Statutory Parking Restrictions Application

381

Parking Restrictions Application

382

No Turn on Red Restriction

- MUTCD Section 2B.54
- MUST work with State Highway Dept.

383

No Turn on Red Restriction

- Review Information in MUTCD

Section 2B.54 No Turn on Red Signs (R10-11 Series, R10-17a, and R10-30)

Standard:

01 **Where a right turn on red (or a left turn on red from a one-way street to a one-way street) is to be prohibited, a symbolic NO TURN ON RED (symbolic circular red) (R10-11) sign (see Figure 2B-27) or a NO TURN ON RED (R10-11a, R10-11b) word message sign (see Figure 2B-27) shall be used.**

Guidance:

02 *If used, the No Turn on Red sign should be installed near the appropriate signal head.*

03 *A No Turn on Red sign should be considered when an engineering study finds that one or more of the following conditions exists:*

A. Inadequate sight distance to vehicles approaching from the left (or right, if applicable);
B. Geometrics or operational characteristics of the intersection that might result in unexpected conflicts;
C. An exclusive pedestrian phase;
D. An unacceptable number of pedestrian conflicts with right-turn-on-red maneuvers, especially involving children, older pedestrians, or persons with disabilities;
E. More than three right-turn-on-red accidents reported in a 12-month period for the particular approach; or
F. The skew angle of the intersecting roadways creates difficulty for drivers to see traffic approaching from their left.

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MUTCD Warrants for No Turn on Red Restriction

A. Inadequate sight distance to approaching vehicles
B. Intersection geometry or operations result in unexpected conflicts
C. Exclusive pedestrian phase
D. Pedestrian conflicts with RTR movement
E. More than 3 RTR crashes in 12 months
F. Skew angle creates difficulties

385

Removal of Hazards: Trees, Plants, Shrubs, etc.

1. The obstruction restricts the stopping sight distance for drivers of through vehicles OR intersection sight distance for drivers entering from side roads
2. The obstruction restricts sight distance of traffic control devices
3. Crash records show the obstruction contributed to crashes

386

Interfering Signs, Lights, Markings

1. Items that interfere with traffic, or may be confused with or obstruct the view or effectiveness of TCDs
   - Colored or flashing lighted signs
   - Other lights, signs, or markings

389

Working with Residents

390

Special Events

- State Traffic Commission
  - Processions, assemblies, special activities
  - Use of state roadways

391

Many Others…

- Traffic signals
- Weight, size, and load restrictions
- School zones
- No passing zones
- Posting of private parking lots
- Handicapped parking

392

In Closing….

393

Objectives

- Did you receive information to:
  - understand the basic concepts, principles, and techniques for evaluating traffic issues
  - develop reasonable alternative solutions for addressing local traffic problems

394

Objectives

- Did you receive information to:
  - practice completing exercises to perform common municipal engineering and traffic studies using real data
  - be able to more effectively communicate with traffic safety experts

395

Don’t forget…

- If you always do what you have always done, you will always get what you have always got

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For More Assistance ...

- Call: **413-545-2604**
- Write: Baystate Roads Program
  University of Massachusetts
  College of Engineering
  214 Marston Hall
  Amherst, MA 01003
- E-mail: info@baystateroads.org